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Status of the MERCURY Laser

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Status of the MERCURY Laser

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The photon collider will require the development of high average-power short-pulse lasers to achieve the required rate of Compton backscattering. The MERCURY laser at LLNL has been under development as part of the Inertial Confinement Fusion program. Its basic parameters are well matched to the photon collider requirements and it is currently being commissioned.

1 Introduction

The MERCURY laser architecture¹ is based on solid-state Ytterbium Strontium Fluor-Appetite (Y:S-Fap) crystals with diode pumping as its laser medium. Super-sonic helium flow over the face of the crystals is employed in order to dissipate the large power lost in the crystals. A seed laser pulse is passed multiple times through the amplifier crystals until it is large enough to extract all of the stored power in the system. The base design of the system produces 100 Joule pulses at a rate of 10Hz with a pulse width of one nanosecond at one micron wavelength. As shown in Figure 1a, the MERCURY consists of two amplifier heads which contain the Y:S-Fap crystals.

The production of such high average-power presents many technical challenges which the program has been solving over the past several years. Initial running with a single amplifier head was completed in summer of 2003. Based on that experience a number of improvements were incorporated into the system before the start of full system operation in January 2004. The plot of the initial low power operation of the full system is shown in Figure 1b.

2 Lessons Learned and System Improvements

Initial running showed damage to the crystal coatings that was correlated to imperfections in the crystal surface. The crystals were reprocessed using Magnetorheological Finishing (MRF) to remove subsurface scratches left by conventional polishing and re-coated. This should greatly improve the lifetime of the coatings.

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Real-time monitoring of diode temperatures was installed, since correlations between excessive spot heating and eventual failure were observed.

Wavefront correctors were installed at the amplifier crystals to improve the wavefront of the laser pulse and improve the power extraction efficiency.

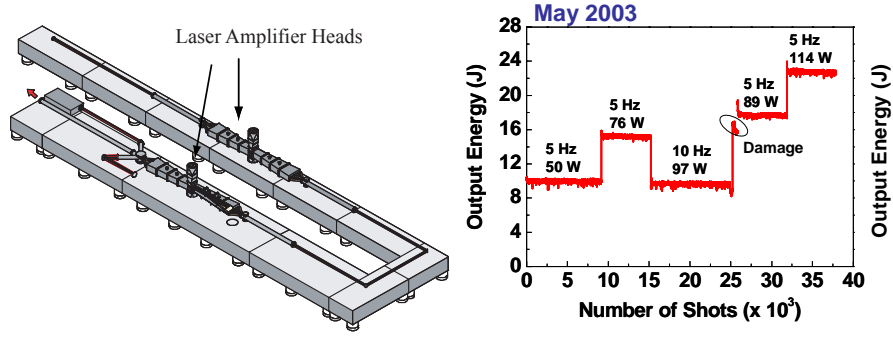


Figure 1: a) The layout of the MERCURY laser, each amplifier head contains seven amplifier crystals. b) Initial running of the full system at lower power.

3 Conclusion

A great deal of progress has been made in the last several years in the technology of high average-power lasers. However, the use of such lasers for a photon collider will require turn-key operation with high reliability and low downtime in order to achieve an acceptable amount of integrated luminosity. Between the present and the start of photon collider operations in ~ 2015 , a well funded program of laser technology development will be required to reach the level of reliable operation needed for a photon collider.

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References

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